REMARKS

IN THE CLAIMS - 35 USC 112

INFORMALITIES:

In compliance with the Examiner's objections because of several informalities, appropriate correction has been performed.

(ref. Paper No. 4, paragraph 2)

ANTECEDENT BASIS:

In compliance with the Examiner's objections because of failing to provide proper antecedent basis in the claims, appropriate correction has been performed. Many items were corrected in the Applicant's invention claims, that lacked proper antecedent basis.

These are important elements of the claimed invention and proper correction was performed in the Claims. Some of the key layers in the claims are enumerated, i.e., "first photoresist layer", "second photoresist layer". The confusion caused by interchanging and combining "dielectric" and "insulation" was corrected in the independent claims 1,11 and 21 according to the Examiner's suggestions.

(ref. Paper No. 4, paragraph 2)

CLAIM REJECTIONS -35 USC 112:

In compliance with the Examiner's objections under 35 USC 112, second paragraph, all the corrections have been performed. The claim language has been amended to make the claims more defined, and less "vague and indefinite". (ref. Paper No. 4, paragraph 2)

ADDITIONAL CORRECTIONS:

Many additional corrections were made to cover all aspects of the Examiner's suggestions, which included a complete review of the claims, and this review included correction of any minor grammatical mistakes.

Note, the term "trench/via" is frequently used in dual damascene technical literature to mean trench and via structure, since both the trench and via are attached and connected together. The "trench/via" term depicts the trench and via layering with trench on top of the via, in the same way, one abbreviates two thin film layers of (A) material and (B) material by the term "A/B".

Corrections have been made to both the specifications and the claims to comply with the Examiner's suggestion to change the "trench/via" terms to "trench and via". The "trench/via" term is not intended to imply "trench or via". (ref. Paper No. 4, paragraph 2)

BRIEF SUMMARY OF THE APPLICANT'S INVENTION:

Key to the Applicant's invention is the subsequent use of two layers of different positive photoresists, possessing different exposure wavelength sensitivities. It is a general object of the present invention to provide a new and improved method of forming semiconductor integrated circuit devices, and more specifically, in the formation of self-aligned dual damascene interconnects and vias, which incorporates two positive photoresist systems, which have different wavelength sensitivities, to form trench and via openings with only a two-step etching process. In addition, the two layers of photoresist exhibit different etch resistant properties, for subsequent selective reactive ion etching steps. The use of a "high contrast" positive photoresist system has been developed wherein the resist system exposure sensitivity is optimized for wavelengths, deep-UV (248nm) for the top layer of resist, the trench pattern, and I-line (365nm) for the bottom layer of resist, the via pattern. The resist system provides a process in dual damascene for trench/via formation and has the following properties: selective etch resistance, thermal stability during processing, ease of processing and developing, and good adhesion properties.

CLAIM REJECTIONS - 35 USC 103

ARGUMENTS:

The Examiner's objections to claims 1-7, 9-17, 19-27,29,30 under 35 USC 103(a), as being unpatentable over Jang (US 6,110,648, hereafter referred to as Jang), in view of Tobben et al.(US 6,103,456, hereafter referred to as Tobben), and further in view of Orvek et al.(US 4,770,739, hereafter referred to as Orvek), are believed to be overcome, based on the following.

(ref. Paper No. 4, paragraph 4)

There are significant difference between the Applicant's invention and Jang's invention. The main focus of the Jang invention is as the title states,"METHOD OF ENCLOSING COPPER CONDUCTOR IN A DUAL DAMASCENE PROCESS." Jang teaches a method of enclosing copper conductors in a protective material. Hence, Jang claims that the problems of corrosion and de-lamination through diffusion of copper are eliminated. The Applicant's inventions is directed toward simplifying a dual damascene process by saving processing steps, reducing etch steps, by the specific use of two different photoresists. The two different photoresists are used in the formation of self-aligned dual damascene interconnects and vias. The Applicant's invention incorporates two positive photoresist

systems, which have different wavelength sensitivities, to form trench and via openings with only a two-step etching process, instead of the convention three etching steps.

Agree with the Examiner's report that Jang does not teach the use of:

A) a top insulating dielectric layer over a three-layer stack (ref. Applicant's claims 1,5,11,15,21,25)

B) the use of a near-UV (365nm) photoresist and a deep UV (268nm) photoresist

(ref. Applicant's claims 1,6,7,11,16,17,21,26,27)

Tobben's invention is primary focused on the prevention of photoresist poisoning caused by reactive gases from a silicon oxynitride layer, which used as a DARC, dielectric anti-reflective coating for a subsequent overlying photoresist layer. There are significant differences between the Tobben disclosure and the Applicant's dual damascene process. Comparing Tobben's figures with that of the Applicant, one notices the absence of two photoresist layers in Tobben, and the presence of the two layers of photoresist in the Applicant's Figures, Fig. 2A and Fig. 2B, the bottom photoresist layer #9, and the top photoresist layer #20. The key to the Applicant's invention is using two different

sensitivity photoresist, as "building blocks" for a dual damascene trench and via process.

The Orvek disclosure is concerned with planarizing an irregular surface with a first layer of planarizing photoresist, the bottom layer. The second layer of photoresist is coated over the first, and forms a top layer. The two resist have different sensitivities to UV light, and the top resist is exposed and patterner. The top resist pattern is then transferred exactly to the bottom resist pattern. This Orvek process produces added processing step and is costly, in that two photoresists are used to define only one pattern. There are major difference between the Orvek process and that of the Applicant's process. The Orvek process use two different photoresists to define only one pattern, whereas the Applicant's process uses two different photoresists to define two patterns, in dual damascene the trench and via.

Finally, the combination of Jang, Tobben and Orvek would still not produce the photoresist stacks found in the Applicant's invention, Fig. 2A and Fig. 2B.

The Examiner's objections to claims 8,18,28 under 35 USC 103(a), as being unpatentable over Jang (US 6,110,648, hereafter referred to as Jang), in view of Tobben et al.(US 6,103,456, hereafter referred to as Tobben), and further in view of Orvek et al.(US 4,770,739, hereafter referred to as Orvek), as applied to claims 1-7,9-17,19-27,29,30 above, and further in view of Pu et al.(US 5,843,847, hereafter referred to as Pu), are believed to be overcome, based on the following.

(ref. Paper No. 4, paragraph 5)

Please refer to the agruments given above, in reference to Paper No. 4, paragraph 4. In regards to the Pu invention, as the title indicates, it is primarily concerned with selective etching processes. It does not address the Applicant's invention and Pu's figures indicate only one photoresist layer, reference Pu figures: Fig. 1A, Fig. 1B, Fig. 1C, and Fig. 1D, in each the photoresist layer is labeled #40.

In closing, the combination of Jang, Tobben, Orvek and Pu, would still not produce the photoresist stacks found in the Applicant's invention, Fig. 2A and Fig. 2B.

In conclusion, for state-of-the-art advanced applications in silicon technology, the Applicant's invention is believed to be patentable over these various references, because there seems to be insufficient basis for concluding that the modification of Prior Art disclosures would have been obvious to one skilled in the art. That is to say, there must be something in the prior art or line of reasoning to suggest that the combination of these various references is desirable. We believe that there is no such basis for the combination of Jang, Tobben, Orvek and Pu.

FINAL REMARKS

The Examiner Kripa Sagar is thanked for carefully examining and reviewing the subject patent application. The specifications and claims have been reviewed in accordance with all the Examiner's kind suggestions, and after amending the specifications and all the claims 1-30 in accordance with the Examiner's helpful suggestions, all claims are now believed to be in condition for allowance.

All rejected claims are now believed to be in allowable condition, and allowance is so requested.

Attached hereto is a marked-up version of the changes made to the specifications and the claims by the current Amendment. The attached page is captioned, "Version With Markings To Show Changes Made."

It is requested that should there be any problems with this Amendment, please call the undersigned Attorney at (845) 452-5863.

Respectfully submitted,

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"Version With Markings To Show Changes Made"

PLEASE SEE THE NEXT PAGE

1. (AMENDED) A method of photoresist processing comprising:

providing a substrate over which is formed composite layers of insulation comprising a first layer of dielectric separated from a second layer of dielectric by an intermediate etch stop layer of dielectric;

forming a top dielectric layer over said composite layers of dielectric;

forming a first photoresist layer over said composite layers of [dielectric] insulation and top insulating layer;

patterning a via hole pattern in said first photoresist layer by exposing to I-line 365nm radiation and developing;

forming a second photoresist layer over via patterned said first photoresist layer;

patterning a trench line pattern in second photoresist layer by exposing to deep-UV 248nm radiation and developing;

etching top and second layer of dielectric underlying first layer of photoresist using the via hole pattern layer;

etching said intermediate layer of dielectric under said second layer of dielectric using the first layer of photoresist as a mask;

etching said composite layer of insulation transferring said trench line pattern into said first layer of photoresist and into said second layer of dielectric and transferring said via hole pattern into said intermediate layer of dielectric and into said first layer of dielectric;

removing said layers of photoresist and filling the trench line and via hole openings with metal.

3. (AMENDED) The method of claim 1, wherein said composite layers of insulation are low dielectric constant dielectric material [which are selected from the group] consisting of $SiOF_x$, $SiOC_x$, $SiOH_x$, where the value of "x" is in range from 0.5 to 1.0, in a thickness range from approximately 4000 to [1200] 12000 Angstroms for said first layer of dielectric and in a thickness range from approximately 4000 to 8000 Angstroms for said second layer of dielectric.

4. (AMENDED) The method of claim 1, wherein said intermediate etch stop layer of dielectric [is selected from the group consisting] consists of silicon nitride, Si_xN_y, where the value of "x" is in range from 2 to 3 and the value of "y" is in a range from 3 to 4, in a thickness range from approximately 200 to 500 Angstroms,

and can used in tandem with another etch stop layer or without said etch stop [layers].

6. (AMENDED) The method of claim 1, wherein said first photoresist layer is positive [type] photoresist [selected from the group] consisting of I-line positive resists, in a thickness range from approximately 6000 to 10000 Angstroms and is selectively sensitive to and exposed to ultraviolet light I-line radiation of wavelength 365nm.

7. (AMENDED) The method of claim 1, wherein said second photoresist layer is positive [type] photoresist [selected from the group] consisting of positive DUV, 248nm photoresist, in a thickness range from approximately 5000 to 10000 Angstroms and is selectively sensitive to and exposed to ultraviolet light deep-UV radiation of wavelength 248nm.

9. (AMENDED) The method of claim 1, wherein the dual damascene [trench/via] trench and via is lined with a diffusion barrier, filled with conducting metal and whereby the excess metal is removed by chemical mechanical polish.

11. (AMENDED) A method of dual damascene patterning by use of two-layered photoresist process, having different wavelength sensitivities for each layer, comprising:

providing a substrate over which is formed composite layers of insulation wherein said composite layers comprise a first layer of dielectric separated from a second layer of dielectric by an intermediate etch stop layer of dielectric and etch stop layer of dielectric below the first layer of dielectric;

forming a top dielectric layer over said composite layers of dielectric;

forming a first photoresist layer over said composite layers of [dielectric] insulation and said top dielectric layer;

patterning a via hole pattern in said first photoresist layer composed by exposing to I-line 365nm radiation and developing said first photoresist layer by using a via hole mask;

forming a second photoresist layer over said first photoresist layer;

patterning a trench line pattern in said second photoresist layer by exposing to deep-UV 248nm radiation and developing said second photoresist layer by using a trench line mask;

etching, in two-step process, said second layer of dielectric underlying said first layer of photoresist using the via hole patterned layer of the first photoresist as a mask and transferring said via hole pattern into said second layer of dielectric;

etching said intermediate layer of dielectric under said second layer of dielectric using the first layer of photoresist as a mask and transferring said via hole pattern in said layer of photoresist into said intermediate layer of dielectric;

etching said composite layer of insulation transferring said trench line pattern into said first layer of photoresist and into said second layer of dielectric to form a trench line opening, and at the same time transferring said via hole pattern into said intermediate layer of dielectric and into said first layer of dielectric to form a via hole opening;

removing said layers of photoresist and any exposed insulating material in the trench line opening and via hole opening;

depositing metal into the trench line and via hole opening with subsequent removal of excess metal by chemical mechanical polishing back, to form inlaid conducting interconnects lines and contact vias, in a dual damascene process.

13. (AMENDED) The method of claim 11, wherein said composite layers of insulation are low dielectric constant dielectric material [which are selected from the group] consisting of $SiOF_x$, $SiOC_x$, $SiOH_x$, where the value of "x" is in range from 0.5 to 1.0, in a thickness range from approximately 4000 to [1200] 12000 Angstroms for said first layer of dielectric and in a thickness range from approximately 4000 to 8000 Angstroms for said second layer of dielectric.

14. (AMENDED) The method of claim 11, wherein said intermediate etch stop layer of dielectric [is selected from the group consisting] consists of silicon nitride, Si_xN_y, where the value of "x" is in range from 2 to 3 and the value of "y" is in a range from 3 to 4, in a thickness range from approximately 200 to 500 Angstroms, and can used in tandem with another etch stop layer or without said etch stop [layers].

16. (AMENDED) The method of claim 11, wherein said first photoresist layer is positive [type] photoresist [selected from the group] consisting of I-line positive resists, in a thickness range from approximately 6000 to 10000 Angstroms and is selectively sensitive to and exposed to ultraviolet light I-line radiation of wavelength 365nm.

17. (AMENDED) The method of claim 11, wherein said second photoresist layer is positive [type] photoresist [selected from the group] consisting of positive DUV, 248nm photoresist, in a thickness range from approximately 5000 to 10000 Angstroms and is selectively sensitive to and exposed to ultraviolet light deep-UV radiation of wavelength 248nm.

19. (AMENDED) The method of claim 11, wherein the dual damascene [trench/via] trench and via is lined with a diffusion barrier, filled with conducting metal and whereby the excess metal is removed by chemical mechanical polish.

21. (AMENDED) A method of dual damascene patterning by use of two-layered photoresist process, having different wavelength sensitivities for each layer, comprising:

providing a substrate over which is formed composite layers of insulation wherein said composite layers comprise a first layer of dielectric separated from a second layer of dielectric by an intermediate etch stop layer of dielectric and etch stop layer of dielectric below the first layer of dielectric;

forming a top dielectric layer over said composite layers of dielectric;

forming a first photoresist layer composed of polymer over said composite layers of [dielectric] insulation and said top dielectric layer;

patterning a via hole pattern in said first photoresist layer composed of polymer, positive type, by exposing to I-line 365nm radiation and developing said first photoresist layer by using a via hole mask;

forming a second photoresist layer composed of polymer over said first photoresist layer;

patterning a trench line pattern in said second photoresist layer composed of, polymer, positive type, by exposing to deep-UV 248nm radiation and developing said second photoresist layer by using a trench line mask;

etching in the first of a two-step selective reactive ion etch process using the following gases, for step one:

CHF_3, C_2F_6, N_2 O_2 Ar / CO, C_4F_8, C_2F_6, Ar, producing trench and via openings;

etching in the second of a two-step selective reactive ion etch process using the following gases, for step two:

CF_4, Ar O_2, CH_3F, removing SiN for bottom of via opening;

etching said second layer of dielectric underlying the first layer of photoresist using the via hole patterned layer of the first photoresist as a mask and

transferring said via hole pattern into said second layer of dielectric, by etch step one above ;

etching said intermediate layer of dielectric under said second layer of dielectric using the first layer of photoresist as a mask and transferring said via hole pattern in said layer of photoresist into said intermediate layer of dielectric, by etch step one above;

etching said composite layer of insulation transferring said trench line pattern into said first layer of photoresist and into said second layer of dielectric to form a trench line opening, and at the same time transferring said via hole pattern into said intermediate layer of dielectric and into said first layer of dielectric to form a via hole opening, by etch step one above;

removing said layers of photoresist and any exposed insulating material in the trench line opening and via hole opening by ashing and by etch step two above;

depositing metal into the trench line and via hole opening with subsequent removal of excess metal by chemical mechanical polishing back, to form inlaid conducting interconnects lines and contact vias, in a dual damascene process.

23. (AMENDED) The method of claim 21, wherein said composite layers of insulation are low dielectric constant dielectric material [which are selected from the group] consisting of $SiOF_x$, $SiOC_x$, $SiOH_x$, where the value of "x" is in range from 0.5 to 1.0, in a thickness range from approximately 4000 to [1200] 12000 Angstroms for said first layer of dielectric and in a thickness range from approximately 4000 to 8000 Angstroms for said second layer of dielectric.

24. (AMENDED) The method of claim 21, wherein said intermediate etch stop layer of dielectric [is selected from the group consisting] consists of silicon nitride, Si_xN_y, where the value of "x" is in range from 2 to 3 and the value of "y" is in a range from 3 to 4, in a thickness range from approximately 200 to 500 Angstroms, and can used in tandem with another etch stop layer or without said etch stop [layers].

26. (AMENDED) The method of claim 21, wherein said first photoresist layer is positive [type] photoresist [selected from the group] consisting of I-line positive resists, in a thickness range from approximately 6000 to 10000 Angstroms and is selectively sensitive to and exposed to ultraviolet light I-line radiation of wavelength 365nm.

27. (AMENDED) The method of claim 21, wherein said second photoresist layer is positive [type] photoresist [selected from the group] consisting of positive DUV, 248nm photoresist, in a thickness range from approximately 5000 to 10000 Angstroms and is selectively sensitive to and exposed to ultraviolet light deep-UV radiation of wavelength 248nm.

29. (AMENDED) The method of claim 21, wherein the dual damascene [trench/via] trench and via is lined with a diffusion barrier, filled with conducting metal and whereby the excess metal is removed by chemical mechanical polish.